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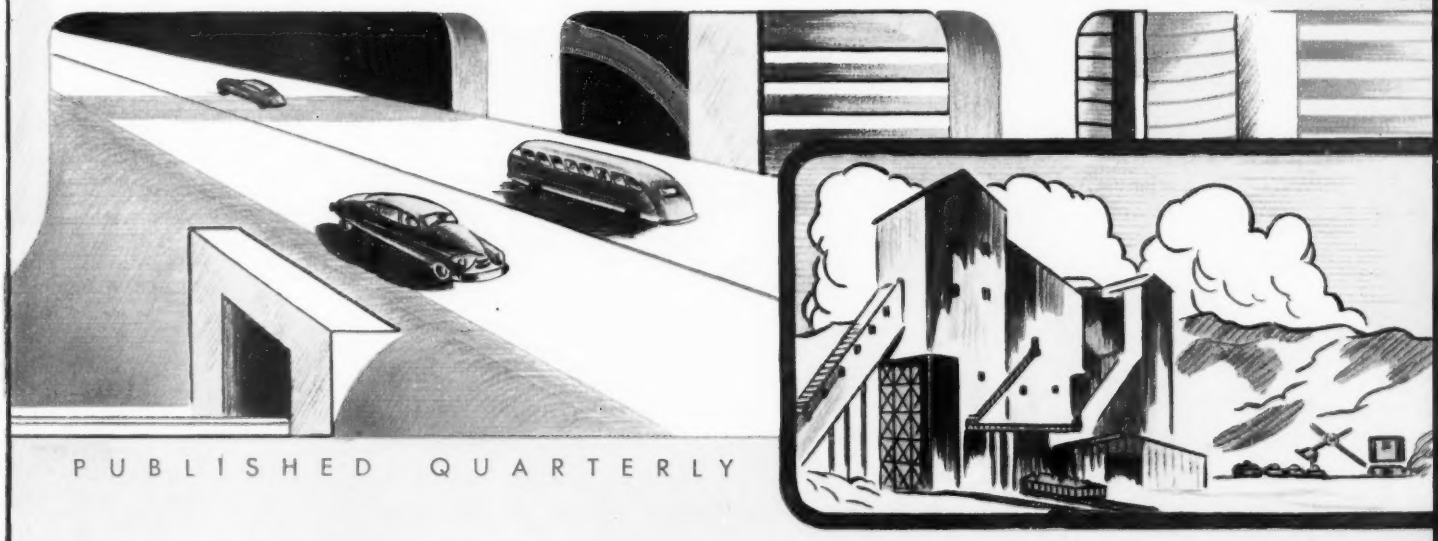

PUBLISHED QUARTERLY

In This Issue

June 1953

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- **Modern Construction of Pavement Bases with Crushed Stone**

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The Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

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CRUSHED STONE JOURNAL

WASHINGTON, D. C.

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The Trend Toward Throughway Construction[1]

By B. D. TALLAMY

Superintendent
New York Department of Public Works
Albany, N. Y.

I HAVE been asked to talk about the trend toward expressway construction. I am pleased to do so, because that is one of the most important parts of our over-all highway problem. Our nation has always been a nation interested in transportation, interested in moving from one area to another, in exploring, in developing, in bettering our economy, in creating new opportunities through transportation.

I remember reading a story not so long ago about the Water-borne Conference of the United States, and I was particularly intrigued by the fact that one of the earliest forms of transportation was by canoe. Actually, there used to be long canoe trains, 400, 500, and 600 canoes in a row, or in caravan, or whatever you might call a procession of canoes of that nature, that would start out from Quebec and Montreal, and work along the shores of the St. Lawrence until they got to the rapids. They would then proceed by portage around those, and go into relatively quiet water again and work their way up along the St. Lawrence some more until they finally reached Lake Ontario. There they would paddle along the shores to the Niagara, portage Niagara Falls and the rapids, proceed up Lake Erie to the Middle West, carrying trinkets for the Indians, stuff brought over from Europe. The Indians would trade furs for them. These were brought back by canoe train again, for sale, manufacture, and export in or from the Montreal area.

That was one of the first forms of transportation in the United States. Then as you know of course, transportation followed foot trails and took the form of more advanced water-borne navigation, pack horse, horseback rider, express rider, and so on. Then there gradually developed a system of highways along the Atlantic Seaboard east of the Allegheny Mountains.

New York did pretty well in those days. We had an outlet to the West up the Hudson River and out the Mohawk to Buffalo and then by the Great Lakes to the Western areas. But Philadelphia was not so fortunately situated. The people could not get across the mountains. They wondered what in the world they could do to improve the pack horse trains, which they were using to carry commodities to the western part of Pennsylvania.

They finally decided, when George Washington was President of the United States, to build a toll road. That was the first throughway, or the first express highway, express by comparison with other highways in those days, that was ever undertaken. It was a private enterprise. A company was authorized to build a route from Philadelphia to Lancaster, 62 miles of 24 ft. construction. They even provided grassed side slopes in cuts and on hills. I do not suppose their shoulders were very big. It did not mention that in the article I read, but it did mention the pains with which they took care of the

1 Presented at the 36th Annual Convention of the National Crushed Stone Association held at the Hotel New Yorker, New York, N. Y., February 2-4, 1953

side slopes, and I presume that that meant they took care of drainage pretty well, too. They used crushed limestone for the construction of the highway primarily. You won't like to hear this, but in some areas they used gravel too.

Actually, they discovered that here at last was a road that became better with use. It proved out both practically and financially. The toll rates were quite high. They went from 1 cent a mile up to 13 1/2 cents a mile, which in those days was a pretty steep rate indeed. But the road paid out, and it continued to be highly successful. It opened up the areas west of the Alleghenies to Philadelphia, and the sea coast, and other areas along that coast.

Their work was a dramatic illustration of the importance of highways. From that example, other toll roads were built, and other free roads throughout the nation.

I think that we owe a great strength in the United States to the fact that historically we have had such a fine transportation system. We have kept pace with the times. We have gone from the canoe trains to other water-borne transportation, from the pack horse to coach, then to our Erie Canal and other canals, and waterway developments throughout the nation. Then came railroads, followed by a revitalization of our entire highway system. In recent years a complete change-over almost in our whole economy came as a result of the automobile age.

Of course, you all know that we did a terrific job in rebuilding our highway system in the twenties. We kept ahead of the automobile industry for quite a while. Then we did an equally poor job during the depression. During the war we were not able to correct the situation. You know all that story. So, now we are faced with a tremendous highway problem.

In New York State, we have made a survey, which is not a statistical survey but one which is based upon an actual mile by mile study of the roads, walking over the highways, looking at the plans, seeing the conditions, comparing them with the traffic, which shows a problem of $2,883,000,000 which should be solved in ten years if we are to bring our system up to adequacy.

A question was asked me not so long ago as to what we meant by adequacy, or what we hoped to accomplish, by this program of nearly $3 billion in ten years. The answer is this. We want to place our highway system—our town highways, our county highways, our state highways, and the arterial routes in the cities which are so urgently needed—in such a condition that year by year all we need to do is to take care of obsolescence and depreciation.

We are not in that position now. Now, we have to take care of that and try to catch up with this immense backlog of construction which has developed in this country during the depression and war years.

You know the economic reasons for the need of conditioning our highways. I will not go into those. But I would like to indicate to you a few trends. We are building expressways, throughways, and we are doing it by the Departments of Public Works and by Highway Commissions as free roads and as toll roads.

You may ask: Why are we building limited access or expressway type highways? Why don't we build the four and six lane roads that we used to build, and still do in some places, and which have proven so helpful in developing the economy of the areas in which they are constructed?

The reason is that we can obtain the same economic advantage by the construction of an expressway without the disadvantage of uncontrolled access. We can stimulate development of abutting lands, we can create business, we can maintain property values or increase them. We can create competitive benefits superior to other areas successfully with the express highway method the same as we did with the old-type road. As a matter of fact, we can do all of this better, because traffic will move a little faster, a little more safely and more securely.

When the old roads (and I say old figuratively; actually, some of them are now only ten or twelve years old) were first constructed, a great economic development frequently took place as a result of their being put in use. In suburban areas all sorts of industries were constructed adjacent to them, subdivisions were created, many new accesses to the highway made and, inside of a ten-year period, there were a number of traffic lights along the highway. The inevitable results were bottlenecks, delays, and traffic congestions that are not good. Unless something is done in those areas now to relieve those congestions through the construction of other routes or reconstruction, those areas will be at a disadvantage in competition with other sections.

For example, I was called upon about a month ago by one of the officials and a part of his staff, of a large corporation. They were very concerned because the highway which borders their plant near

Buffalo, and over which most of their help is transported, is so congested that it takes at least a half-hour or three-quarters of an hour longer for their employees to go to that plant, or to go home than it does to other new industries in that area. The company is finding it extremely difficult to secure the number of employees it needs.

In addition to that, the company is losing employees. When they are questioned to find out what the problem is, the reason given is that it takes too long to get to and from work. Jobs are available at so-and-so, and transportation takes only half the time.

That is just one example of the economic effect of poor highways on industry. That highway was in fine condition not too many years ago, but it is all built up along it now, and this congestion has been created as a result of the highway itself.

We build highways in order to create business and commercial and agricultural opportunities, and that is fine. But if we can build these highways, create such opportunities, and at the same time lengthen the efficient life of the highway, so we do not so soon have to build another expensive route, that is what we ought to do, and the way to do it is through the construction of express highways.

Since abutting property traffic cannot go directly to these routes, it has to go along a regular state or county highway, or a city street and when it does reach the main route it is conducted to the expressway through properly designed traffic interchanges. Consequently, we do not have the interruptions to traffic which occur on the regular highway system. Therefore, express routes serve traffic efficiently for a very much longer period of time.

The increased cost is relatively light. In many cases, it is less expensive to do it that way than to reconstruct existing routes because of damage to abutting properties that would be sustained in the event we widened a three-lane highway to a six-lane divided expressway, which would be essential in many instances.

Every state has this highway traffic problem that I have described. I do not care where you fellows come from. I know from personal knowledge, through discussions with your highway commissioners, and through the testimony that has been presented to the Congress, that you are all in the same boat, and that your highways need reconstruction just as ours do in New York State.

The cost of that reconstruction is greater than you can finance out of normal tax revenues, at least as they exist now. In recognition of that fact, and of the extreme need for the construction of these expressways that I have spoken of in certain areas, the states have resorted to the construction of toll roads, and I think that is entirely sound.

Actually, if we can lift a $300 or a $500 million load off the budget of the state in carefully selected cases, and benefit our highway system to that extent, I think we ought to do it. Apparently, that opinion is held by a great many state legislators and governors, because now in thirty states of the United States toll highways are under construction, or under detailed planning and investigation. No doubt the vast majority of those which are just in the planning stage will ultimately go ahead.

There are several things that I would like to point out to you about our method of doing toll road construction in New York State. These may be of interest to you because I know that the people in your respective states will look to you for information and for counselling, and probably frequently for actual engineering opinions.

As far as the financing is concerned, I fully believe, after the experience we have had in New York State, that it is absolutely desirable, and of extreme importance, to have the state guarantee the toll road authority's obligations. By doing that, you do get a great reduction in interest costs. I am certain that the reduction of interest on Thruway Authority bonds will be at least 1 per cent. In that event it will mean a saving to the Authority of over $100 million. That saving in operation, in continuing costs during the life of the bond issues, means we can do many desirable things which other toll roads have not been able to do. The most important thing, of course, is that we can create an opportunity to owners of passenger cars registered in the State of New York to purchase a special annual Thruway permit. The engineers have recommended $10 a year for that permit. It will give passenger car owners the privilege of using the Thruway from one end to the other, or locally, as much as they want without any additional cost, except in one instance where they cross the Hudson River on a three-mile bridge. There the annual permit is good for a fifty per cent reduction in the fare.

It would be extremely difficult, if not impossible, to give that opportunity for low cost transportation without the big saving in interest we secure.

We did not know whether or not the people would place the state's guarantee behind the Thruway Authority bond, when the initial legislation passed, which gave the opportunity to the people to vote on that question. All that was done during the period of consideration of that constitutional question was the presentation of the facts to the electorate. There was no high-pressure salesmanship, just presentation of the facts. And the public voted a little better than four to one in favor of the proposition.

I would like to say at this time, that at the time of the consideration of that referendum your members in New York State helped in disseminating factual information and it was of great assistance. So did the Good Roads Association of the State of New York. They did an excellent job, and spent a good deal of time and effort in disseminating facts, and I can say the same thing about the Automobile Dealers Association and practically every organization in the State of New York which is interested in highway transportation. They bent their shoulders to the wheel on that vital question.

You may be interested to know that we have completed our first financing. We borrowed $60 million on short term notes. It was cheaper for us to do that than to start right out issuing bonds, and we have the opportunity of financing by notes to a considerable extent rather than going to bonds because of the guarantee of the state. We always know that we can sell the bonds because of the guarantee. Other authorities cannot be sure. They have to start right out and either sell all their bonds or get a commitment for which they have to pay from 1/2 to 3/4 of 1 per cent.

We have borrowed this $60 million at 1.1 per cent interest. That which is not already used to pay contractors, is invested in short-term government issues paying 1.61 per cent, so we are actually making 1/2 of 1 per cent on our temporary surplus. That, I think, is pretty good business, and it is only possible because of the state guarantee.

The Thruway is being constructed, as you know, as a limited access highway, ultimately three lanes in each direction divided by a wide mall. In no place will the mall be less than 20 ft., and in a majority of cases it will be far wider than that. We believe that wherever we can buy right of way at a reasonable cost we should widen the mall for safety reasons. It has been the experience on many express roads that a car will sometimes jump the mall onto the wrong lane and cause an accident. Furthermore, there is a hazardous monotony in driving a car on an expressway which is just like a railroad. and the two tracks are always the same distance apart weaving through the country. So, we endeavored in the design to take every possible advantage of nature, locate the highways at different levels, sometimes have one route lead off and go the other side of a woods where the timberland or second growth timber in that area is inexpensive, and sometimes we stride a swamp. In one place we actually have a small river running right down the mall.

Incidentally, it is a trout river. I expect we will see some trout fishermen there. We have made some provision for the fishermen to get underneath the highway to go to the stream. As you go by, you will be able to see them fly casting there, I hope.

Those are the things we try to do to break up monotony. You may be interested in knowing how we are getting along. Very well, I believe. We now have nearly $300 million worth of construction underway. We expect to have the entire project under contract from New York to Buffalo by June of this year. The first toll section of 150 miles in length from Batavia to Utica, we expect to be open the latter part of this year. Practically the entire route from New York to Buffalo will be completed by the end of 1954.

The big bridge across the Hudson is coming well. We have all our foundation contracts in effect, and the contractors are working. The first 8,000 ft. of the superstructure has been awarded to the American Bridge Company. The three remaining contracts for the superstructure will be awarded within the next six weeks. So much for that.

I want to do a little philosophizing with you now, I think, in connection with this toll road problem. What I am going to tell you is not a firm conviction of mine at all; it is just an idea that I want you to think about, because maybe something like this will develop, maybe it won't. Maybe you will think, after considering it, that something should be done to push it. I do not know. But I do think it is worthy of consideration.

It involves federal aid, it involves toll roads, and it involves this user tax mentioned, this excise tax of the Federal Government.

As far as the toll road is concerned, I pointed out to you this very extensive development is taking place. It is a financial plus physical need which creates it. We have to have the highways that are the toll roads. We have to have them now. We

cannot wait for them. In the normal course of events, it would take thirty-five to forty years to get them. We need them right now. The traffic needs them, the economy needs them, our national defense may seriously need them. We cannot wait for them.

There is not enough money, so the states are turning to toll roads. There is enough money there. The public is perfectly willing to pay for the use of these toll roads, because they are special roads which give them special benefits. All roads could not be toll roads, that is obvious. But in these certain cases they offer them enough special benefits so that the public is perfectly willing to pay for them, as is evidenced by the experience of our various turnpike authorities.

Actually, they save in cash, out-of-pocket expenditure, the amount of toll, without considering the incidental benefits.

Since the only road that can become a self-liquidating road is the most important road in the state, because it has to carry the most traffic in order to be self-liquidating, these roads that are being developed as toll roads are a part of the most important highway system of the nation. In other words, they are mainly on the interstate system, because you cannot build the other roads as self-supporting projects.

That may sound good, but these roads are developing without any coordination one with the other. The design standards might vary, the geometry of the road may be different from its neighbor and the types of interchanges may be entirely different. Allowable truck loads and sizes may be different. I wonder if it makes sense to have the most important highway system of the nation very rapidly develop in that fashion. I doubt it.

On the other hand, there is no cure to it that I can see, unless federal aid, which is available for the interstate system, is also made available for the toll road system. That would not create a diversion of federal funds from the other urgent highway needs, because the interstate system money can only be used on the interstate system anyway, and if the interstate system is a toll road system, why can't federal aid be used on the toll road system as a basic principle?

There might be certain conditions and provisions which should be met before federal aid can be available, and I will indicate that, but as a basic principle it would seem to be desirable, because it would immediately make it possible to coordinate the development of the most important highway system of the nation, and to see that it is built uniformly according to the same general standards and operated in the same general way.

From the practical point of view, I do not believe you can accomplish this uniformity by persuasion. I doubt if there is any turnpike authority that would willingly, without some inducement like I cited, take on voluntarily the headaches, the delays and the problems which are involved in this coordination, or involved in securing federal aid for improvement. They would shun away from that like nobody's business, unless there was some incentive or motive for it.

The conditions for federal aid might well be state guarantee of the financing, or the sale of state general obligation bonds for the construction of a highway, so that the traveling public will get the benefit of the lowest possible rates.

If that were a condition, I can readily see that any state in the future which wanted to proceed with a toll road project would very seriously indeed, consider the question of going ahead without a state guarantee, if it were going to lose the opportunity of expediting through federal aid the payment of these bonds and making it a free road, or in reducing the rates to the user or both.

If that is so, and the toll road systems in the various states have a plan for licensing of passenger cars, similar to that proposed by the New York State Thruway Authority, after a few years of operation and the heavy debt service load is reduced, it would be a relatively easy matter to work out some plan of reciprocity between the states for passenger car operation on the toll road system. It would seem to me that on the most important highway system in the nation reciprocity would be a desirable thing.

There are lots of problems, but it seems to me that if the various states gradually work into the position where they permit unlimited use on their own system through a license plate, that it would be a relatively easy step to go from that situation to reciprocity. For example, in New York, if the Thruway Authority lost the revenue because of reciprocity that out-of-state cars would normally pay, it might create a financial problem. But if that loss were offset by federal aid, then there would not be any financial problem, and reciprocity could be accomplished.

I am not, as I say, giving you this as any firm conviction on my part, but as a long-range objective that we might all want to aim at, and I think if it could be accomplished it probably would be very beneficial to the nation.

I want to clear up one point. I am not advocating at the moment increased appropriations for federal aid, and I am not arguing the federal aid picture, but I am saying that if federal aid is made available, and it is now available, for interstate highways, then that money ought to be available for the toll road portion of the interstate highway system, if it meets certain basic standards.

That brings me to the point of the highway user tax, or excise tax, as far as the Federal Government is concerned. Right now, as was pointed out, that is about $2 billion a year. I would not be a bit surprised but that this year the motor fuel tax alone would be about $1 billion. Certainly, the trend points to that.

The federal aid highway system is now securing $550 million a year in federal aid out of that highway user excise gross tax. The states have the primary responsibility of maintaining our highway system. There is no question about that. That is basic in a nation made up of several states, as ours is. It is basic from actual experience.

Right now, when the states are actually spending about 88 per cent of the entire cost of constructing and maintaining and reconstructing the highway system, the Federal Government is spending only 12 per cent.

Likewise, it is pretty generally felt that the highway motor fuel tax should be basically a state tax. It is a field of taxation which the state should have prior right to, and that feeling is very widespread. I know from personal experience in talking not only with highway people but talking with people in all walks of life.

First of all, may I say that I believe the Federal Government should definitely make it clear and establish a policy insofar as it can constitutionally do so, not to take further advantage of that tax field. Secondly, if the Federal Government is expending $1 billion on the federal aid system and it is collecting $2 billion the $1 billion difference which is not used for federal aid should be relinquished to the states since the states have the primary responsibility for maintaining and constructing the national highway system.

I do not mean that somebody can wave a magic wand and make it possible at once for the Federal Government to give up a billion dollars worth of revenue. But I think it would be sensible to cut federal expenses wherever possible along the line, and then as a result of that, to return to the state, the highway user tax in excess of the amount of federal aid, which under such circumstances, can be done, particularly in view of the fact that the highway systems of all the states and the nation are in such dire need of immediate expansion or reconstruction.

This limited access or thruway principle that I am supposed to talk about today, whether it is a toll road or a free road, is basically sound because it is the highway which in the long run will be the cheapest, and certainly it will create values in the area almost immediately, and before I close, I want to point out that that has been our experience in New York.

Along one short section of the Thruway in the central part of the state, we bought land for about $500 or $600 an acre. Before we established the Thruway definitely in its present location, we had several locations under consideration. The General Electric Corporation wanted to know exactly where we were going to put it. They coordinated their own expansion plans with ours. They had to know, because they were going to depend upon that highway. We coordinated our planning with theirs.

Their project and our project went ahead. Their project was followed by subdivision development, building of local roads with streets, water lines, and sewers, by the influx and development of additional industries, truck terminals, et cetera. A great development is taking place there. Now, land right alongside of what used to cost a few hundred dollars is selling for $5,000 and $6,000 an acre. That is in a matter of three or four years.

That shows what highways mean. When we have such a large highway problem, and since highways are so essential to our other economy, to our national defense, everything almost, and when we consider the urgent need of maintaining our economy at a high level, particularly in view of the terrific national debt we have to carry, certainly every effort must be strained toward solving the highway problem.

It is urgent for you to put your shoulder to the wheel in helping to solve that problem in your various states. We need you and I am sure that we can count on you.

Modern Construction of Pavement Bases with Crushed Stone[1]

By CHARLES E. PROUDLEY

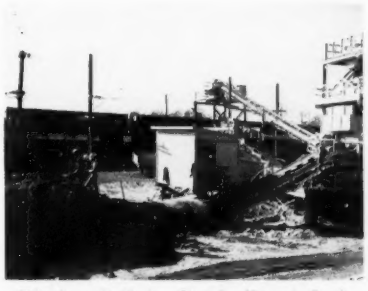
Chief Materials Engineer
North Carolina State Highway & Public Works Commission
Raleigh, N. C.

THIS method of construction, as I understand, is quite new in the Eastern part of the United States. Our division engineer in the central part of North Carolina became interested in this method of construction somewhat by accident. The specifications for the materials to be used in the construction of an access road which was going to be subjected to heavy traffic required a stone type of base. The contractor failed to select his materials properly, for he thought it was to be a soil type base instead of a stone type base. The division engineer asked the contractor to get some stone to add to the soil to bring it up to the type of construction he wanted. The result was that the contractor not only got some concrete stone to mix with the soil, but he also put it through a concrete mixer, added some water to it. This road when completed carried exceptionally heavy traffic so successfully that the division engineer felt justified in going to the Commission and asking that a project be set up on a primary highway carrying the heaviest traffic in North Carolina, using this type of base with a bituminous wearing surface. The Commission acceded to this request and set up Project 6587 for a road to be built between Charlotte and Concord, North Carolina, which was to be 24 ft. wide and 16.55 miles in length, consisting of a stabilized aggregate base course 14 in. thick, upon which a double surface treatment wearing surface was to be placed. This paper is essentially a description of the construction of the stabilized aggregate base course on this project.

Stabilized aggregate for this job consisted of four parts of crushed stone from the Midland Quarry of the Superior Stone Company and one part of selected topsoil. The special features of the job were the accurate control of gradation of aggregates to yield a uniform product, the addition of a constant percentage of water which had been determined by the laboratory to be the optimum for economical compaction on the road, the addition of calcium chloride to the top course, and the blending of all ingredients in a continuous mixing operation using a pugmill.

The crushed stone was run of crusher passing a 2 in. screen from which some of the minus 1/2 in. size had been removed to give the most desirable gradation when combined with the binder soil. Laboratory tests were made in advance to establish the proportions for maximum density. It was found that the 4:1 mix gave a weight per cubic foot of 142 lb. when compacted in accordance with AASHO Method T 99, which meant that the per cent of solids was 83.5 or that there were 16.5 per cent voids.

The soil was hauled to the quarry a distance of 5 miles for most of the project but 25 miles some of the time. The soil would be classified as an A-2-4 which is a good lean sandy soil with a plasticity index of never more than 2 and generally nonplastic. The liquid limit was 18 to 22.



Binder Soil in Stockpile at Left Is Proportioned Onto Belt Conveyor in Tunnel. Calcium Chloride Flows From Hopper (Center) Onto Belt Going to Pug Mill Under Stone Bin at Right

The specifications for gradation of the stabilized aggregate and the grading actually used on this job were as follows:

The plasticity index was limited to 6 and the liquid limit to not more than 25 per cent.

The Highway Commission's Division Engineer, M. E. Beatty, who waged a difficult battle to have his ideas approved on this job, insisted that the materials be blended in a mixing plant. It was soon discovered that vigorous mechanical mixing such as was secured in the asphalt mixing plant type of pug-

[1] Presented at the 36th Annual Convention of the National Crushed Stone Association held at the Hotel New Yorker, New York, N. Y., February 2-4, 1953

Gradation of Stabilized Aggregate

Sieve Size	Specifications Total Passing, per cent	Average Used Total Passing, per cent
2 in.	100	100
1 in.	75 to 90	91[a]
1/2 in.	60 to 75	69
No. 4	45 to 60	50[b]
No. 40	15 to 30	20
No. 200	not less than 5 nor more than 2/3 of the amount passing No. 40 sieve.	9[c]

[a] The 91 per cent is 1 per cent out of the specification limits but was considered immaterial.
[b] Variations in amount passing the No. 4 sieve were between 47 and 53 per cent.
[c] As much as 13 per cent would have been permitted by the specifications.

mill was a necessity. Also uniformity demanded that vibrating pan proportioning equipment be used for stone, soil, and calcium chloride. Even these could not be relied upon and one inspector constantly watched the belt on which the blend was carried to the pugmill and if any of the materials were observed to vary in amount the conveyor belt was stopped instantly and not started until the condition had been corrected. After proportioning, no stockpiling was permitted. The moist, stabilized aggregate was trucked an average 19 miles to the project and spread by means of Jaeger spreaders.

Inspector Is Prepared to Shut Down Operations Should Any Ingredient Appear to be Improperly Proportioned as It Goes Into Pug Mill Under Screened Lid Below Him

Two spreaders were operated side by side to give a full width of 24 1/2 ft. for each layer. A string line on each side was used to assure proper coverage by successive layers. The project was divided into sections approximately 2 miles long and the first two layers placed and compacted before proceeding with the last two. This was to protect the subgrade from damage by rain or traffic. The first two layers were each 5 in. loose which compacted to 3 3/4 in. each. The third layer was 4 2/3 in. loose compacted to 3 1/2 in. and the top layer, in which 7 lb. of calcium chloride per ton were incorporated, was placed 4 in. loose which gave 3 in. compacted. Core measurements taken during the construction gave information from which corrections in these thickness measurements were made in order to assure a full 14 in. final base thickness.

Trucks Are Loaded by Belt Directly From Blending and Mixing Plant

The contract called for equipment sufficient to mix, spread and compact 2,000 tons per day. A daily average of between 1,700 and 1,800 tons was the actual rate although the highest tonnage on one day was 3,100.

Consolidation of each layer was accomplished with rollers having a weight of 330 lb. per inch width of tread. The first rolling had to be done with a rubber-tired straight traffic roller. This "set" or bonded the surface particles so that subsequent rolling could be done with steel-wheeled rollers and would not pick up the base material. The favored roller was the ring roller which consists of railroad car wheels with the flanges trimmed off mounted the same as the rubber-tired traffic roller wheels. Wobble-wheel rollers are not effective. Three passes of the rollers for each loose inch thickness of base usually accomplished the required density. The density was checked by tests, however, before proceeding with subsequent operations.

In spite of the fact that the desired density has been reached by rolling, the stability of the base will not be developed fully until there has been time for some of the water to disappear. On this job about 2 per cent or less residual moisture gave maximum bearing capacity. In other words, after rolling to maximum density a period of curing must be allowed for the base to attain its full strength and this curing time is one or two days in fair weather.

Density of the subgrade was checked by means of the Rainhart Volume Meter. The density of the base courses was determined by use of a circular form consisting of a welded and machined ring of

1/4 in. steel plate 5 in. high and 18 in. in diameter. The inside is beveled for approximately 1 1/2 in. at the bottom to facilitate cutting out the base material as closely to an 18 in. diameter as possible. The ring is worked down by picking out the base material inside down to the bottom of the layer being tested. The aggregate removed is dried and weighed. The depth to which the ring has been driven is measured and, using a correction factor previously established, the volume of the hole is computed. The dry weight per cubic foot can be computed from this information. Compaction is not considered to be adequate until it has reached 100 per cent of that established by the laboratory which in this case was 142 lb. per cu. ft. The compaction determinations ranged from 100 to 105 per cent of AASHO Method T 99 for most of the job and slightly higher in some instances.

Two Jaeger Spreaders Operating Side by Side Spread Base Mixture for Full Width of 24 1/2 ft. Grader Built up Shoulders as Each Layer Was Placed

Calcium chloride was used in the top layer to maintain stability, prevent dusting and raveling until it could be primed for surface treatment. Another device for assuring a satisfactory prime of the base was the use of a drag broom behind the ring roller when the top layer was being compacted. The broom has steel or fibre bristles which distribute the fines and give a smoother surface of uniform texture.

A Close-up of Base Aggregate Immediately After Spreading

Another important construction requirement was that the shoulders be built up simultaneously with each layer and that rolling of the joint between them be done so as to support the base material with shoulder material as a form and yet not run the risk of base material being contaminated with shoulder material. This rolling of the shoulder and base together provides an impervious seal to prevent infiltration of water. Except when caught by heavy rain before a layer of the base was compacted there was no need of shoulder drains since the compacted base was actually impervious as a result of its careful blending and uniformity through plant control.

Initial Compaction with Multiple Tire Pneumatic Roller

For those who are interested in the characteristics of the stone, the Midland Quarry has been identified as a slate, has a specific gravity of 2.80 and Los Angeles wear of about 22 per cent.

The average week-day traffic on the old road in August 1952, was 7445 vehicles of which 2585 were trucks and of the trucks 805 were the very large tractor truck semi-trailer type. With the dual lane provided by the job described here, approximately half this intensity will be carried. The pavement has been open to traffic since September 1952 and there have been no signs of base failures. The bituminous surface treatment was intended to be temporary and there was considerable apprehension over its service life on a primary highway; however, except for a negligible number of small failures of the treatment which occurred shortly after turning traffic on it, the performance has been practically perfect. The idea is, of course, that after weak spots have developed and anticipated settlement has occurred the permanent leveling course and wearing surface will be applied. So far there is no urgency for the final stage of construction on this pavement.

Ring Rollers Used for Obtaining Ultimate Compaction

Manufacturers Division — National Crushed Stone Association

These associate members are morally and financially aiding the Association in its efforts to protect and advance the interests of the crushed stone industry. Please give them favorable consideration whenever possible.

Allis-Chalmers Mfg. Co.
Milwaukee 1, Wis.
Crushing, Screening, Washing, Grinding, Cement Machinery; Motors; Texrope Drives; Centrifugal Pumps; Tractors

American Cyanamid Co.
Explosives Department
30 Rockefeller Plaza, New York 20, N. Y.
Explosives and Blasting Supplies

American Manganese Steel Division
American Brake Shoe Co.
109 North Wabash Ave., Chicago 2, Ill.
Manganese Steel Castings, Power Shovel Dippers, Material Handling Pumps, Heat and Corrosion Resistant Castings, Reclamation and Hard-Facing Welding Materials

American Pulverizer Co.
1249 Macklind Ave., St. Louis 10, Mo.
Manufacturers of Ring Crushers and Hammermills for Primary and Secondary Crushing

American Steel & Wire Division
Rockefeller Bldg., 614 Superior Ave., N. W., Cleveland 13, Ohio
Wire Rope, Aerial Wire Rope Tramways, Electrical Wires and Cables, Welded Wire Fabric, Concrete Reinforcing, Wire Nails, Fencing, Netting

Atlas Powder Co.
Wilmington 99, Del.
Industrial Explosives and Blasting Supplies

Bacon-Greene & Milroy
29 Washington Ave., Hamden 14, Conn.
"FARREL-BACON" Jaw Crushers for Primary and Secondary Operations, Conveyors, Elevators, Rolls, Screens

Bacon-Pietsch Co., Inc.
75 North Maple Ave., Ridgewood, N. J.
Manufacturers of Farrel-Bacon Crushers and Allied Screening and Conveying Equipment

Baldwin-Lima-Hamilton Corp.
Construction Equipment Division
South Main St., Lima, Ohio
Power Shovels, Draglines, Cranes, Bins, Conveyors and Idlers, Crushers and Pulverizers, Feeders, Plants—Crushing and Portable, Washing Equipment

Barber-Greene Co.
631 West Park Ave., Aurora, Ill.
Portable and Permanent Belt Conveyors, Belt Conveyor Idlers, Bucket Loaders both Wheel and Crawler Mounted, Asphalt Mixers and Finishers, Coal Handling Machines

Buchanan, C. G., Crushing Machinery Division, Birdsboro Steel Foundry and Machine Co.
1941 Furnace St., Birdsboro, Pa.
Primary, Secondary, and Finishing Crushers and Rolls

Bucyrus-Erie Co.
South Milwaukee, Wis.
Excavating, Drilling and Material Handling Equipment

Buda Co.
154th St. and Commercial Ave., Harvey, Ill.
Diesel and Gasoline Engines; Material Handling Equipment; Lifting Jacks; Earth Drills and Maintenance of Way Equipment

Caterpillar Tractor Co.
Peoria 8, Ill.
Track-Type Tractors, Bulldozers, Earthmoving Scrapers, Motor Graders, Heavy-Duty Off-Road Hauling Units, Diesel Engines, and Diesel Electric Generating Sets

Chain Belt Co.
P. O. Box 2022, Milwaukee 1, Wis.
Rex Conveyors, Elevators, Feeders, Idlers; Drive and Conveyor Chains, Power Transmission Equipment; Concrete Mixers, Pavers, Pumpcrete and Portable Pumps

Continental Gin Co.
4500 Fifth Ave., S., Birmingham 2, Ala.
Conveyors—Belt, Screw, Flight and Underground Mine; Elevators—Bucket and Screw; Feeders—Apron, Belt, Reciprocating, Table, and Screw; Drives—V-Belts, Chains and Sprockets, Gears and Speed Reducers

Cross Engineering Co.
P. O. Box 16, Carbondale, Pa.
Screen Plates and Sections, Perforated Plate for Vibrating, Rotary and Shaking Screens

Cummins Engine Co., Inc.
Fifth and Union Sts., Columbus, Ind.
Lightweight Highspeed Diesel Engines (50-550 Hp.) for: On-Highway Trucks, Off-Highway Trucks, Buses, Tractors, Earthmovers, Shovels, Cranes, Industrial and Switcher Locomotives, Air Compressors, Logging Yarders and Loaders, Oil Well Drilling Rigs, Centrifugal Pumps, Generator Sets and Power Units, Work Boats and Pleasure Craft

Manufacturers Division—National Crushed Stone Association
(continued)

Deister Machine Co.
1933 East Wayne St., Fort Wayne 4, Ind.
Deister Plat-O Vibrating Screen, Deister Compound Funnel Classifier

Detroit Diesel Engine Division General Motors Corp.
13400 West Outer Drive, Detroit 28, Mich.
Light Weight, Compact 2 Cycle Diesel Engines and "Package Power" Units for All Classes of Service

Diamond Iron Works, Inc.
1728 North Second St., Minneapolis 11, Minn.
Jaw and Roll Crushers; Vibrator, Revolving, and Scrubber Screens; Drag Washers; Bucket Elevators; Belt Conveyors; Bins; Apron and Plate Feeders; Portable Gravel and Rock Crushing, Screening, and Washing Plants; Stationary Crushing, Screening, and Washing Plants; Hammermills

Du Pont, E. I., de Nemours & Co., Inc.
Wilmington 98, Del.
Explosives and Blasting Accessories

Eagle Iron Works
129 Holcomb Ave., Des Moines 13, Iowa
Fine Material Screw Washers—Classifiers—Dehydrators; Coarse Material Screw and Log Washers—Dewaterers; Water Scalping and Fine Material Settling Tanks; and "Swintek" Screen Chain Cutter Dredging Ladders

Easton Car & Construction Co.
Easton, Pa.
Off-Highway Transportation: Dump Trailers, Truck Bodies, and Cars for Mines, Quarries, and Earth Moving Projects

Ensign-Bickford Co.
Simsbury, Conn.
Primacord-Bickford Detonating Fuse and Safety Fuse

Euclid Road Machinery Co.
1361 Chardon Road, Cleveland 17, Ohio
Heavy-Duty Trucks and Dump Trailers for "Off-Highway" Hauls, Loaders for Earth Excavation, Single and Twin Engine Earth Moving Scrapers

Even Spread Co.
P. O. Box 98, Owensville, Ohio
Power Spreaders and Attachments for Agricultural Lime and Fertilizer

Frog, Switch & Mfg. Co.
Carlisle, Pa.
Manganese Steel Department—Manufacturers of "Indian Brand" Manganese Steel Castings for Frogs, Switches, and Crossings, Jaw and Gyratory Crushers, Cement Mills, Mining Machinery, Etc., Steam Shovel Parts

General Electric Co.
1 River Road, Schenectady 5, N. Y.
Electric Motors, Controls, Locomotives, Coordinated Electric Drives for: Shovels, Drag Lines, Conveyors, Hoists, Cranes, Crushers, Screens, Etc.; Coordinated Power Generating and Distributing Systems Including Turbine Generators, Switchgear, Transformers, Cable, Cable Skids, Load Center Substations

Gill Rock Drill Co.
Lebanon, Pa.
Well Drill Tools and Supplies

Goodrich, B. F., Co.
500 South Main St., Akron 18, Ohio
Industrial Rubber Products — Flexible Bonded Edge Conveyor and Elevator Belting, Cord Conveyor Belting, Highflex and Cord Transmission Belting; Grommet V-Belts; Type 54 Air Hydraulic Control, Burst Proof Steam, Water, Suction and Other Hose; Armorite Chute Lining; Rubber and Koroseal Protective Clothing and Footwear; Tires and Tubes (Automobile, Truck, Off-the-Road, Industrial), Batteries

Goodyear Tire & Rubber Co., Inc.
Akron 16, Ohio
Airfoam; Mechanical Goods—Belting (Conveyor, Elevator, Transmission), Hose (Air, Water, Steam, Suction, Miscellaneous), Chute Lining (Rubber); Rims (Truck and Tractor); Storage Batteries (Automobile, Truck, Tractor); Tires (Automobile, Truck, Off-the-Road); Tubes (Automobile, Truck, Off-the-Road, LifeGuard, Safety Tubes, Puncture Seal Tubes)

Gruendler Crusher and Pulverizer Co.
2915 North Market St., St. Louis 6, Mo.
Rock and Gravel Crushing and Screening Plants, Jaw Crushers, Roll Crushers, Hammermills, Lime Pulverizers

Gulf Oil Corp. Gulf Refining Co.
Gulf Bldg., Pittsburgh 19, Pa.
Lubricating Oils, Greases, Gasoline and Diesel Fuels

Haiss, George, Mfg. Co., Inc., Division of Pettibone Mulliken Corp.
5720 Empire State Bldg., New York 1, N. Y.
Bucket Loaders, Buckets, Portable and Stationary Conveyors, Car Unloaders

Harnischfeger Corp.
4400 West National Ave., Milwaukee 14, Wis.
A complete line of Power Excavating Equipment, Overhead Cranes, Hoists, Smootharc Welders, Welding Rod, Motors and Generators, Diesel Engines

HarriSteel Products Co.
420 Lexington Ave., New York 17, N. Y.
Woven Wire Screen Cloth

Manufacturers Division—National Crushed Stone Association
(continued)

Hayward Co.
50 Church St., New York 7, N. Y.
Orange Peel Buckets, Clam Shell Buckets, Electric Motor Buckets, Automatic Take-up Reels

Heidenreich, E. Lee, Jr.
Consulting Engineers
75 Second St., Newburgh, N. Y.
Plant Layout, Design, Supervision; Open Pit Quarry Surveys; Appraisals—Plant and Property

Hendrick Mfg. Co.
Carbondale, Pa.
Perforated Metal Screens, Perforated Plates for Vibrating, Shaking, and Revolving Screens; Elevator Buckets; Test Screens; Wedge Slot Screens; Open Steel Floor Grating

Hercules Powder Co.
Wilmington 99, Del.
Explosives and Blasting Supplies

Hetherington & Berner Inc.
701-745 Kentucky Ave., Indianapolis 7, Ind.
Asphalt Paving Machinery, Sand and Stone Dryers, Dust Collectors

Hewitt-Robins Incorporated
666 Glenbrook Road, Stamford, Conn.
Belt Conveyors (Belting and Machinery); Belt and Bucket Elevators; Car Shake-outs; Feeders; Industrial Hose; Screen Cloth; Sectional Conveyors; Skip Hoists; Stackers; Transmission Belting; Vibrating Conveyors, Feeders, and Screens; Design and Construction of Complete Plants

Hughes Tool Co.
P. O. Box 2539, Houston 1, Texas
Drills and Drilling Equipment

Illinois Powder Mfg. Co.
506 Olive St., St. Louis 1, Mo.
Gold Medal Explosives

Ilyus, Brown & Associates
120 Day Ave., S.W., Roanoke 16, Va.
Consulting Engineering in Rock, Coal and Ore Preparation Plants, Materials Handling, Surveys, Appraisals, and Analysis

Ingersoll-Rand Co.
11 Broadway, New York 4, N. Y.
Rock Drills, Quarrymaster Drills, Jackbits, Bit Reconditioning Equipment, Portable and Stationary Air Compressors, Air Hoists, Slusher Hoists, Air Tools, Diesel Engines, Pumps

Insley Manufacturing Corp.
801 North Olney St., Indianapolis 6, Ind.
Concrete Carts and Buckets, ½ Yd. Cranes and Shovels

International Harvester Co.
180 North Michigan Ave., Chicago 1, Ill.
Motor Trucks, Diesel and Gasoline Power Units; Crawler Tractors; Industrial Wheel Tractors

Iowa Manufacturing Co.
916 16th St., N.E., Cedar Rapids, Iowa
Rock and Gravel Crushing, Screening, Conveying and Washing Plants. Hot and Cold Mix Asphalt Plants, Stabilizer Plants, KU-BIT Impact Breakers, Screens, Elevators, Conveyors, Portable and Stationary Equipment, Hammermills, Bins

Jaeger Machine Co.
550 West Spring St., Columbus 16, Ohio
Portable and Stationary Air Compressors, Self-Priming Pumps, Truck Mixers, Concrete Mixers, Road Paving Machinery, Hoists and Towers

Jaite Co.
Jaite, Ohio
Multiwall Paper Bags, Sewn and Pasted Style for Packaging Lime, Cement, Plaster, Etc.

Jeffrey Manufacturing Co.
East First Ave., Columbus 16, Ohio
Material Handling Machinery, Crushers, Pulverizers, Screens, Chains

Johnson-March Corp.
1724 Chestnut St., Philadelphia 3, Pa.
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Joy Manufacturing Co.
333 Henry W. Oliver Bldg., Pittsburgh 22, Pa.
Drills: Blast-Hole, Wagon, Rock, and Core; Air Compressors: Portable, Stationary, and Semi-Portable; Aftercoolers; Portable Blowers; Carpullers; Hoists; Multi-Purpose and Portable Rock Loaders; Air Motors; Trench Diggers; Belt Conveyors; Drill-Bit Furnaces; "Spaders"; "String-a-Lite" (Safety-Lighting-Cable); Backfill Tampers; Drill Bits: Rock and Core

Kennedy-Van Saun Mfg. & Eng. Corp.
2 Park Ave., New York 16, N. Y.
Crushing, Screening, Washing, Conveying, Elevating, Grinding, Complete Cement Plants, Complete Lime Plants, Complete Lightweight Aggregate Plants, Synchronous Motors, Air Activated Containers for Transportation of Pulverized Material, Cement Pumps, and Power Plant Equipment

Kensington Steel Co.
505 Kensington Ave., Chicago 28, Ill.
Manganese Steel Castings, Dipper Teeth, Crawler Treads, Jaw Plates, Concaves and Hammers

King Powder Co., Inc.
Cincinnati, Ohio
Detonite, Dynamites, and Blasting Supplies

Koehring Co.
3026 West Concordia Ave., Milwaukee 16, Wis.
Excavating, Hauling and Concrete Equipment

Manufacturers Division—National Crushed Stone Association
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Le Roi Co.
Cleveland Rock Drill Division
12500 Berea Road, Cleveland 11, Ohio
Air Compressors—Portable 60 Cfm. to 600 Cfm. Gas or Diesel; Tractairs—Combined Tractor with 105 Cfm. Air Compressor; Engines; Generator Sets; Rock and Wagon Drills; Jumbo Drill Rigs, Drifters, Stopers, Self Propelled Drill Rigs

Linde Air Products Co., Division of Union Carbide and Carbon Corp.
30 East 42nd St., New York 17, N. Y.
Oxygen, Acetylene Welding Equipment and Supplies

Link-Belt Co.
300 West Pershing Road, Chicago 9, Ill.
Complete Stone Preparation Plants; Conveyors, Elevators, Screens, Washing Equipment, Speed-O-Matic Shovels—Cranes—Draglines and Power Transmission Equipment

Ludlow-Saylor Wire Co.
634 South Newstead Ave., St. Louis 10, Mo.
Woven Wire Screens and Wire Cloth of Super-Loy, All Commercial Alloys and Metals

Mack Manufacturing Corp.
350 Fifth Ave., New York 1, N. Y.
On- and Off-Highway Trucks, Tractor Trailers, Six-Wheelers, from 5 to 30 Tons Capacity, both Gasoline- and Diesel-Powered

Marion Power Shovel Co.
617 West Center St., Marion, Ohio
A Complete Line of Power Shovels, Draglines, and Cranes

McLanahan & Stone Corp.
200 Wall St., Hollidaysburg, Pa.
Complete Pit, Mine, and Quarry Equipment —Crushers, Washers, Screens, Feeders, etc.

Michigan Power Shovel Co.
270 Miller St., Benton Harbor, Mich.
Truck Mounted and Crawler Shovel Crane 3/8 and 1/2 Cu. Yd.

Murphy Diesel Co.
5317 West Burnham St., Milwaukee 14, Wis.
Murphy Diesel Engines Ranging from 90 to 190 Continuous Horsepower at 1200 Rpm. and Packaged Type Generator Sets 60 to 133 Kw. for All Classes of Service

New York Rubber Corp.
100 Park Ave., New York 17, N. Y.
Conveyor Belting: Stonore, Dependable, and Cameo Grades; Transmission Belting: Silver Duck Duroflex, Soft Duck Rugged, Commercial Grade Tractor

Nordberg Mfg. Co.
3073 South Chase Ave., Milwaukee 7, Wis.
Cone, Gyratory, Jaw and Impact Crushers; Grinding Mills; Stone Plant and Cement Mill Machinery; Vibrating Screens; Grizzlies; Diesel and Steam Engines; Compressors; Mine Hoists; Track Maintenance Tools

Northern Blower Co.
6409 Barberton Ave., Cleveland 2, Ohio
Dust Collecting Systems, Fans—Exhaust and Blower

Northwest Engineering Co.
135 South LaSalle St., Chicago 3, Ill.
Shovels, Cranes, Draglines, Pullshovels

Olin Industries, Inc.
Explosives Division
East Alton, Ill.
Dynamite, Black Powder, Blasting Caps, Blasting Supplies

Osgood Co.
Cheney Ave., Marion, Ohio
Power Shovels, Cranes, Draglines, Hoes, Etc., 3/8 to 2 1/2 Cu. Yd.

Pennsylvania Crusher Co.
Liberty Trust Bldg., Broad and Arch Sts., Philadelphia 7, Pa.
Single Roll Crushers, Impactors, Hammermills, Ring Type Granulators, KUE-KEN Jaw Crushers, KUE-KEN Gyracones, Dixie Non-Clog and Standard Hammermills

Pettibone Mulliken Corp.
4710 West Division St., Chicago 51, Ill.
Buckets, Dragline and Parts; Loaders—Car, Bucket; Plants—Asphalt, Portable

Pioneer Engineering Works, Inc.
1515 Central Ave., N. E., Minneapolis 13, Minn.
Jaw Crushers, Roll Crushers (Twin and Triple), Vibrating and Revolving Screens, Feeders (Mechanical, Grizzly, Apron, and Pioneer-Oro), Belt Conveyors, Portable and Stationary Crushing and Screening Plants, Washing Plants, Mining Equipment, Cement and Lime Equipment, Asphalt Plants

Pit and Quarry Publications
431 South Dearborn St., Chicago 5, Ill.
Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Concrete Manufacturer, Concrete Industries Yearbook

Quaker Rubber Corp.
Tacony and Milnor Sts., Philadelphia 24, Pa.
Conveyor Belts, Hose, and Packings

Rock Bit Sales and Service Co.
350 Depot St., Asheville, N. C.
Tungsten Carbide Detachable Bits, "Rock Bit" Drill Steel Inlaid with Tungsten Carbide, Carbon Hollow Drill Steel, Alloy Hollow Drill Steel

Manufacturers Division—National Crushed Stone Association
(concluded)

Rock Products
309 West Jackson Blvd., Chicago 6, Ill.

Rogers Iron Works Co.
11th and Pearl Sts., Joplin, Mo.
Jaw Crushers, Roll Crushers, Hammermills, Vibrating Screens, Revolving Screens and Scrubbers, Apron Feeders, Reciprocating Feeders, Roll Grizzlys, Conveyors, Elevators, Portable and Stationary Crushing and Screening Plants, Mine Hoists, Drill Jumbos and Underground Loaders

Screen Equipment Co., Inc.
1754 Walden Ave., Buffalo 25, N. Y.
SECO Vibrating Screens

Simplicity Engineering Co.
Durand, Mich.
Simplicity Gyrating Screen, Simplicity D'centegrator, Simplicity D'watering Wheel

SKF Industries, Inc.
Front St. and Erie Ave., P. O. Box 6731,
Philadelphia 32, Pa.
Anti-Friction Bearings—Self-Aligning Ball, Single Row Deep Groove Ball, Angular Contact Ball, Double Row Deep Groove Ball, Spherical Roller, Cylindrical Roller, Ball Thrust, Spherical Roller Thrust; Pillow Block and Flanged Housings—Ball and Roller

Smith Engineering Works
532 East Capitol Drive, Milwaukee 12, Wis.
Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants

Stedman Foundry & Machine Co., Inc.
Aurora, Ind.
Stedman Impact-Type Selective Reduction Crushers, 2-Stage Swing Hammer Limestone Pulverizers

Stephens-Adamson Mfg. Co.
Aurora, Ill.
Belt Conveyors, Elevators, Feeders, Car Pullers, Screens, Skip Hoists, Complete Plants

Talcott, W. O. & M. W., Inc.
91 Sabin St., Providence 1, R. I.
Belt Fasteners, Belt Lacing, Conveyor Belt Fasteners, and Patch Fasteners

Taylor-Wharton Iron & Steel Co.
High Bridge, N. J.
Manganese and other Special Alloy Steel Castings; Dipper Teeth, Fronts and Lips; Crawler Treads; Jaw and Cheek Plates; Mantles and Concaves; Pulverizer Hammers and Liners; Asphalt Mixer Liners and Tips; Manganese Nickel Steel Welding Rod and Plate

Thew Shovel Co.
East 28th St. and Fulton Rd., Lorain, Ohio
Power Shovels, Cranes, Crawler Cranes, Locomotive Cranes, Draglines, Diesel Electric, Gasoline, 3/8 to 2 1/2 Cu. Yd. Capacities

Torrington Co.
Bantam Bearings Division
3702 West Sample St., South Bend 21, Ind.
Anti-Friction Bearings; Roller Bearings: Spherical, Tapered, Straight, Ball, Needle

Traylor Engineering & Mfg. Co.
Allentown, Pa.
Stone Crushing, Gravel, Lime, and Cement Machinery

Trojan Powder Co.
17 North 7th St., Allentown, Pa.
Explosives and Blasting Supplies

Tyler, W. S., Co.
3615 Superior Ave., N. E., Cleveland 14, Ohio
Woven Wire Screens; Ty-Rock, Tyler-Niagara and Ty-Rocket (Mechanically Vibrated) Screens; Hum-mer Electric Screens; Ro-Tap Testing Sieve Shakers and Tyler Standard Screen Scale Sieves

Universal Engineering Corp.
625 C Ave., N. W., Cedar Rapids, Iowa.
Jaw Crushers, Roll Crushers, Hammermills, Complete Crushing, Screening, and Loading Plants, Either Stationary or Portable for Stone Aggregates or Aglime, Portable and Stationary Washing Plants, Asphalt Plants, and Impact Breakers

Vibration Measurement Engineers
7665 Sheridan Road, Chicago 26, Ill.
Specialists in Blasting Complaint Investigations; Seismological Surveying; Expert Testimony in Blasting Litigation

Werco Steel Co.
2151 East 83rd St., Chicago 17, Ill.
Crusher Jaws, Roll Shells, Mantles, Bowl Liners, Conveyor and Elevator Chain, All Types Wear Resistant Steel Manganese and Alloy Steel Castings, Screen Plate—Perforated Steel, Screen Sections and Decks

Weston Dump Body Co.
326 S.W. 11th St., Des Moines 9, Iowa
Combination Lime, Sand, and Gravel Body; Special Bodies for Quarry and Pit Work

White Motor Co.
842 East 79th St., Cleveland 1, Ohio
On- and Off-Highway Trucks and Tractors—Gasoline- and Diesel-Powered; Industrial Engines, Power Units, Axles, Special Machine Assemblies; All Classes of Service